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13. ABSTRACT (Maximum 200 words)

We have completed the final construction of the sound-deaden listening room and the digital library of stored words, numbers, and letters, from nine English speaking males. We conducted pilot experiments on 20 subjects listening to one and two sound sources at a time. The results of the pilot experiments indicated that the sound room was well calibrated and allowed us to determine that a few of the words, letters, and numbers should be re-recorded. In addition the pilot experiment suggested a few modification to our protocol. The new utterances have been recorded, the protocol modifications made, and a new set of 10 subjects were tested. The results from this additional set indicated that we had a good listening room, set of utterances, and procedure. From October until January of 1993 we will test the headphone listening protocol making adjustments were necessary. We plan to collect data in the full experiment starting late January 1994.

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Progress reports on Research Activity Associated with Air Force Office of Scientific Research Support

Multiple Sound Source Determination, W.A. Yost, R.H. Dye,
Jr. and S. Sheft

We have completed the final construction of the sound-deaden listening room and the digital library of stored words, numbers, and letters, from nine English speaking males. We conducted pilot experiments on 20 subjects listening to one, two and three sound sources at a time. These results indicated that listeners could do a good job of judging words and sound location for up to three simultaneous loudspeakers. The results of the pilot study allowed us to determine that a few of the words, letters, and numbers should be re-recorded. In addition the pilot experiment suggested a few modifications to our protocol. Specifically, we added a part in which the listeners will be asked to go through the experiment a second time, in order to get a better measure of "learning." The new utterances have now been recorded and tested. The protocol modifications were made and a new set of 10 subjects were tested. The results from this additional test indicated that we had a good listening room, an

appropriate set of utterances, and that the procedure was a reasonable one for the undergraduate pool from which we obtain our listeners. From October until January of 1993 we will be testing the monaural listening part of the experiment. In this part the sounds from the listening room will be picked up by a single microphone and played to one headphone of the listener who is seated in a sound-proof room at a location remote from the listening room. We plan to start the full scale experiments in both the listening room and the monaural condition during January 1994. We will present the results of this work at the 1994 meeting of the Acoustical Society of America in Cambridge MA.

In addition, in another pilot experiment we have measured the MDI effect in the listening room. We found that the ability to detect modulation of a tone at one speaker is interfered with by a modulated tone coming from a different speaker. Thus, the MDI effect exists even for spatially separated signals, although the magnitude of the effect is less when the sounds come from different loudspeakers than when they come from the same speaker.

We also observed that modulation seem to make the Franssen effect even stronger. That is, if the modulated tone came on in one speaker slightly before that in the other speaker, all of the sound was located at the leading speaker. The strength of this localization to the leading speaker, was stronger when the tones were modulated than when they were unmodulated. We plan to find an objective psychophysical procedure to measure this effect.

Sound Localization, R. H. Dye, Jr. and W.A. Yost

The main thrust of the work this past year has been to develop and refine a psychophysical procedure that allows one to characterize listeners as *spectrally analytic* or *spectrally synthetic* in binaural lateralization tasks. We have developed a stimulus-classification paradigm that allows one to assess the relative contribution of target and distractor components in judgments of the perceived laterality of signals presented through headphones. In this task, the interaural differences (time or level) of the target and the distractors vary from trial to trial, and the listeners are asked to indicate whether the

target was lateralized to the left or right of the intracranial midline. One tone serves as the target and one tone serves as the distractor. For each block of 100 trials, the target and the distractor are presented at 10 different interaural differences. Each possible pairing of target and distractor interaural difference is presented once (in a random order) during each block of trials. A cue interval, consisting of a diotic presentation of the target component alone, precedes each test interval. Subjects are instructed to indicate whether the target component appeared to the left or right of the intracranial midline.

Left-right judgments are accumulated across a fixed number (10 or 20) of repetitions of each condition and then displayed as a joint function of the target (x-axis) and distractor interaural differences (y-axis). Target weights are derived from the slope of the linear boundary providing the best segregation of left and right responses ($m = -w_T/w_D$) according to a criterion which minimizes the sum of the Euclidean distances between the boundary and "misclassified" left and right responses.

Target weights near 1.0 indicate judgments that are independent of the distractor interaural difference, while weights near 0.5 indicate equal weighting of the target and distractor. Weights less than 0.5 indicate greater weight being given to the distractor than the target.

During the past year, a study of the effect of duration on the ability of listeners to segregate targets based on interaural differences of time (IDTs) was completed (for 753-Hz targets and 553-Hz distractors). Six of the nine subjects showed increasing w_T s with duration (which varied from 25 to 400 ms). The remaining three showed little change with duration: one was analytic at all durations (w_T s near 1.0), one was synthetic at all durations (w_T s near 0.5), and one was intermediate (w_T s). A second study examined the ability of listeners to lateralize 753-Hz targets based on interaural differences of level (IDLs) as a function of the distractor frequency (253 Hz, 353 Hz, 553 Hz, 953 Hz, 1253 Hz, 1753 Hz, and 2753 Hz). Two of the four listeners yielded target weights near 1.0 when the frequency separation between the target and distractor

was large. Two weighted the target and distractor equally under the same conditions. All show a low-frequency dominance, whereby the lower frequency is weighted more heavily than the higher frequency *regardless of whether* it is the target or the distractor when the two are within several hundred Hz of one another.

A study is currently underway in which the target is presented with an IDT and the distractor component is presented with an IDL. Preliminary data show that time and level differences are processed in a spectrally synthetic manner under the same conditions in which target and distractor time differences and target and distractor level differences were synthetically processed. In other words, spectrally remote distractors possessing a different binaural cue than the target influence target laterality in the same manner as distractors possessing the same binaural cue as the target, as though interaural time and level trade across the frequency domain.

Amplitude Modulation in Sound Source Determination, W.A.
Yost, S. Sheft

The work investigates the role of cross-spectral envelope processing in spectral grouping within the context of sound source determination. Recent work has investigated the effect of prior stimulation on the cross-spectral processing of AM. Thresholds were measured for detecting AM of a 2049-Hz probe carrier in the presence of a two-tone masker complex (909 and 4186 Hz). The probe and masker were modulated in-phase at 10 Hz. The modulated probe was preceded by either a 200-ms 2049 Hz tone burst (precursor) or an unmodulated carrier fringe. Precursor and masker onsets were synchronous, with the interval between precursor offset and probe onset (Δt) either 0, 40, or 160 ms. The precursor was either unmodulated, modulated at 10 Hz in-phase with the masker, modulated at 10 Hz anti-phasic to the masker, or modulated at 20 Hz. For Δt 's of 0 and 40 ms, modulation of the precursor lowered probe AM detection thresholds with performance generally best with 10-Hz precursor AM. Results then show that the processing of probe modulation is affected

by prior stimulation. In the fringe conditions, the unmodulated probe carrier preceded the masker onset, with the probe- and masker-modulation onsets synchronous. Fringe duration was either 50, 100, or 200 ms. The addition of the fringe improved performance only with the 50 ms fringe. This finding suggests a limited temporal extent to spectral segregation based on onset asynchrony.

Processing Harmonicity and Intensity of Complex Signals,
W.A. Yost, and S. Sheft

As a consequence of a visit from Roy Patterson, of Cambridge England, the Parmly Hearing Institute's first Visiting Scholar, we made a fascinating discovery which will occupy a great deal of our effort in the coming months. We discovered at least two ways of generating the stimulus we refer to as iterated ripple noise, which are simulations of a sound and its many echoes or reflections. These two versions of iterated ripple noise often produce very different spectral patterns, but yet can yield stimuli that are difficult, or in some cases, impossible to discriminate one from the other. These

Iterated ripple noise stimuli differ in either the pitch or the pitch strength of the complex repetition pitch produce by ripple noises. We have been unable to find a spectral rule that can account for these difficult discriminations. However, the autocorrelation function produces a set of simple rules that have allowed us to describe the psychophysical discrimination data. Perhaps, even more importantly, we can show that a simple transform of the information in the Patterson-Holdsworth auditory image model produces a type of autocorrelation output that also accounts for the data. Since the model is based on probable physiological mechanisms that are both simpler and more physiological realizable than autocorrelation, we feel that the discriminability can be accounted for by physiological circuits which we should be able to investigate in the chinchilla. This work maybe the first clear cut example of how the current spectral models of complex pitch processing can not account for the way in which complex pitch is processed. The work with the model suggests that time based models are better able to account for these and other complex pitch data.

B. Publications/Presentations in 1993-94.:

Dye, R. H., Niemiec, A. J., and Stellmack, M. A. (1994). "Lateralization on the Basis of Interaural Envelope Delays: The Effect of Randomizing Component Starting Phase," Journal of the Acoustical Society of America 95.

Dye, R. H., Yost, W. A., Stellmack, M. A., and Sheft, S. (1994). "A Stimulus Classification Procedure for Assessing the Extent to Which Binaural Processing Is Spectrally Analytic or Synthetic, Journal of the Acoustical Society of America, in press

Dye, R. H. (1994). "The Relative Contributions of Targets and Distractors in Judgments of Laterality Based on Interaural Differences of Level," in Binaural and Spatial Hearing (eds. R. H. Gilkey and T. R. Anderson), Lawrence Erlbaum, Associates.

Dye, R. H. "The Relative Contributions of Targets and Distractors in Laterality Judgments," J. Acoust. Soc. Am. 93, 2349.

Grange, A.N. and Yost, William A., Effects of different samples of reproducible noise on detection of a 20-Hz wide interaural phase shift centered on 500 Hz, Journal of the Acoustical Society of America, 1993

Patterson, Roy D, Allerhand Mike, Zhang, C. Robinson, Ken, Yost, William A. Measuring and Modeling the Pitch Strength of Iterated Ripple Noise, Association for Research in Otolaryngology, St. Petersburg Beach, 1993

Sheft, S., and Yost, W.A. (1993). "Effect of prior stimulation on modulation detection interference," J. Acoust. Soc. Am. 93, 2326-2327.

Shofner, W.P. and Sheft, S. (1993) Spectral representation of envelope beat frequency in the discharge of cochlear nucleus units in the chinchilla. J. Acoust. Soc. Am. 93: 2410.

Shofner, W.P. and Sheft, S. (in review) Detection of bandlimited noise masked by wideband noise in the chinchilla. submitted to Hearing Res.

Shofner, W.P., W.A. Yost, and Sheft, S. (1993) Effects of masker level and bandwidth conditions on noise increment detection in chinchillas. Abstr. 16th Midwinter Meeting Assoc. Res. Otolaryngol. p. 153.

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Stellmack, M. A. and Dye, R. H. (1993). "The Combination of Interaural Information across Frequencies: The effects of number and spacing of components, onset asynchrony, and harmonicity" Journal of the Acoustical Society of America 93, 2933-2947.

Yost, William A. Tonal Temporal Modulation Transfer Function, Journal of the Acoustical Society of America,

under review

Yost, William A. Yost, Sound Source Determination in Multisource Environments, Air Force Office of Scientific Research Workshop, Dayton Ohio, 1993

Yost, William A., The Cocktail Party Effect: Forty Years Later, Conference on Localization, Wright Patterson Air Force Base, 1993

Yost, William A., Sound Source Determination: Across-Frequency Effects, Conference on Implantable Prosthetic Devices, Rhode Island, 1993

Yost, William A. Fundamentals of Hearing: An Introduction, Academic Press, New York (Third edition of Fundamentals of Hearing, but with Academic Press and with William Yost as the sole author), 1994

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Yost, W.A., Fay, R.R., Popper, A. (Co-Editors), Psychoacoustics, Springer Verlag, 1993

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Yost, William A. Factors Controlling Modulation Detection Interference (MDI), Hearing Research, under review

Yost, William A. Auditory Cognition, book review of Thinking in Sound, Science 263, 108-109, 1994

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Yost, William A., Perceptual Models of Localization, Audio Engineering Society Conference on Perception of Reproduced Sounds, Denmark, 1993

Yost, William A., Localization in Three Dimensions, Midwest Society of Audio Engineering, Chicago, 1993

Yost, William A., Hot Topics in Psychological Acoustics, Acoustical Society of America, Denver, 1993

PIADC

Determination of Multiple Sound Sources

P.I. William A. Yost

Loyola University

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A. Publications

Stellmack, M. A. and Dye, R. H. "The Combination of Interaural Information across Frequencies: The effects of number and spacing of components, onset asynchrony, and harmonicity" Journal of the Acoustical Society of America 93, 2933-2947. 1993.

B. Books or Chapters

Yost, William A. Perceptual Models of Localization, in Proceedings of Perception of Reproduced Sound, Audio Engineering Society, 12, 1993

Yost, W.A., Fay, R.R., Popper, A.(Co-Editors), Psychoacoustics, Springer Verlag, 1993

Yost, William A. Overview of Psychoacoustics, in Psychoacoustics,(W.A. Yost, R.R. Fay, and A. Popper, eds), Springer Verlag, 1993

Yost, William A and Stanley Sheft. Auditory Perception, in Psychoacoustics, (W.A. Yost, R.R. Fay, and A. Popper, eds), Springer Verlag, 1993

C. Graduate Assistants

Grange, Tony, Psychology, Loyola University, PhD, USA

D. Post-Doctorates

None

E. Awards

Yost, William A. "Loyola University Faculty Member of the Year", Loyola University, 1993.